

This listing of claims will replace all prior versions, and listings, of claims in the application:

1 Claim 1 (currently amended): A method for use in a
2 multi-stage switch including
3 - a number, $k \times n$, of output ports,
4 - a plurality of central modules, and
5 - a plurality of input modules, each including k
6 groups of n virtual output queues and outgoing links
7 coupled with each of the plurality of central modules,
8 for scheduling a ~~the~~ dispatch of cells stored in the
9 virtual output queues, the method comprising:
10 a) matching a non-empty virtual output queue of an
11 input module with an outgoing link in the input
12 module, wherein the outgoing link has an associated
13 master arbitration operation for selecting one of the
14 k groups of n virtual output queues; and
15 b) matching the outgoing link with an outgoing link
16 of one of the central modules.

1 Claim 2 (original): The method of claim 1 wherein the act
2 of matching a non-empty virtual output queue of an input
3 module with an outgoing link in the input module includes:
4 i) sending, on behalf of each non-empty virtual
5 output queue, a request to slave arbiters, each
6 of the slave arbiters being associated with one
7 of each of the outgoing links of the input
8 module, and each of the slave arbiters being
9 associated with the group of virtual output
10 queues to which the non-empty virtual output
11 queue belongs;

12 ii) sending, on behalf of each group of virtual
13 output queues to which a non-empty virtual output
14 queue belongs, a request to master arbiters, each
15 of the master arbiters being associated with one
16 of each of the outgoing links of the input
17 module;
18 iii) selecting, with each of the master
19 arbiters, a virtual output queue group having at
20 least one non-empty virtual output queue, from
21 among one or more virtual output queue groups
22 that sent a request;
23 iv) selecting, with each of the slave arbiters,
24 a non-empty virtual output queue, belonging to
25 its associated group, from among one or more
26 virtual output queues that sent a request; and
27 v) selecting, with the arbiter of the each of
28 the selected non-empty virtual output queues of
29 each of the selected virtual output queue groups,
30 an outgoing link from among the one or more
31 candidate outgoing links, each of the one or more
32 candidate outgoing links being associated with a
33 master arbiter that selected the virtual output
34 queue group and a slave arbiter that selected the
35 non-empty virtual output queue.

1 Claim 3 (original): The method of claim 2 wherein the act
2 of matching a non-empty virtual output queue of an input
3 module with an outgoing link in the input module occurs
4 within one cell time slot.

1 Claim 4 (original): The method of claim 2 wherein an act
2 of selecting, with a master arbiter, a virtual output queue

3 group having at least one non-empty virtual output queue,
4 is done in accordance with a round robin discipline.

1 Claim 5 (original): The method of claim 2 wherein an act
2 of selecting, with a slave arbiter, a non-empty virtual
3 output queue, belonging to its associated group, is done in
4 accordance with a round robin discipline.

1 Claim 6 (original): The method of claim 2 wherein the act
2 of selecting, with the arbiter of the each of the selected
3 non-empty virtual output queues of each of the selected
4 virtual output queue groups, an outgoing link from among
5 the one or more candidate outgoing links, is done in
6 accordance with a round robin discipline.

1 Claim 7 (original): The method of claim 2 wherein the acts
2 of
3 i) sending, on behalf of each non-empty virtual
4 output queue, a request to slave arbiters, each
5 of the slave arbiters being associated with one
6 of each of the outgoing links of the input
7 module, and each of the slave arbiters being
8 associated with the group of virtual output
9 queues to which the non-empty virtual output
10 queue belongs;
11 ii) sending, on behalf of each group of virtual
12 output queues to which a non-empty virtual output
13 queue belongs, a request to master arbiters, each
14 of the master arbiters being associated with one
15 of each of the outgoing links of the input
16 module;

17 iii) selecting, with each of the master
18 arbiters, a virtual output queue group having at
19 least one non-empty virtual output queue, from
20 among one or more virtual output queue groups
21 that sent a request;
22 iv) selecting, with each of the slave arbiters,
23 a non-empty virtual output queue, belonging to
24 its associated group, from among one or more
25 virtual output queues that sent a request; and
26 v) selecting, with the arbiter of the each of
27 the selected non-empty virtual output queues of
28 each of the selected virtual output queue groups,
29 an outgoing link from among the one or more
30 candidate outgoing links, each of the one or more
31 candidate outgoing links being associated with a
32 master arbiter that selected the virtual output
33 queue group and a slave arbiter that selected the
34 non-empty virtual output queue,
35 are performed at least twice within one cell time slot.

1 Claim 8 (original): The method of claim 1 wherein the act
2 of matching the outgoing link of the input module with an
3 outgoing link of one of the central modules includes:
4 i) sending a request for the outgoing link of the input
5 module to an arbiter for each of the outgoing links of
6 the central modules that leads towards an output port
7 associated with the virtual output queue matched with the
8 outgoing link of the input module; and
9 ii) selecting with the arbiter of each of the outgoing
10 links of the central modules, an outgoing link of an
11 input module from among those that sent a request.

1 Claim 9 (original): The method of claim 8 wherein the act
2 of selecting with the arbiter of each of the outgoing links
3 of the central module, an outgoing link of the input module
4 that broadcast a request, is done based on a round robin
5 discipline.

1 Claim 10 (original): A method for use in a multi-stage
2 switch including

3 - a number, $k \times n$, of output ports,
4 - a plurality of central modules, and
5 - a plurality of input modules, each including k
6 groups of n virtual output queues and outgoing links
7 coupled with each of the plurality of central modules,
8 for matching a non-empty virtual output queue of an input
9 module with an outgoing link in the input module, the

10 method comprising:

11 a) sending, on behalf of each non-empty virtual
12 output queue, a request to slave arbiters, each of the
13 slave arbiters being associated with one of each of
14 the outgoing links of the input module, and each of
15 the slave arbiters being associated with the group of
16 virtual output queues to which the non-empty virtual
17 output queue belongs;

18 b) sending, on behalf of each group of virtual output
19 queues to which a non-empty virtual output queue
20 belongs, a request to master arbiters, each of the
21 master arbiters being associated with one of each of
22 the outgoing links of the input module;

23 c) selecting, with each of the master arbiters, a
24 virtual output queue group having at least one
25 non-empty virtual output queue, from among one or more
26 virtual output queue groups that sent a request;

27 d) selecting, with each of the slave arbiters, a
28 non-empty virtual output queue, belonging to its
29 associated group, from among one or more virtual
30 output queues that sent a request; and
31 e) selecting, with the arbiter of the each of the
32 selected non-empty virtual output queues of each of
33 the selected virtual output queue groups, an outgoing
34 link from among the one or more candidate outgoing
35 links, each of the one or more candidate outgoing
36 links being associated with a master arbiter that
37 selected the virtual output queue group and a slave
38 arbiter that selected the non-empty virtual output
39 queue.

1 Claim 11 (original): The method of claim 10 wherein the
2 act of matching a non-empty virtual output queue of an
3 input module with an outgoing link in the input module
4 occurs within one cell time slot.

1 Claim 12 (original): The method of claim 10 wherein an act
2 of selecting, with a master arbiter, a virtual output queue
3 group having at least one non-empty virtual output queue,
4 is done in accordance with a round robin discipline.

1 Claim 13 (original): The method of claim 10 wherein an act
2 of selecting, with a slave arbiter, a non-empty virtual
3 output queue, belonging to its associated group, is done in
4 accordance with a round robin discipline.

1 Claim 14 (original): The method of claim 10 wherein the
2 act of selecting, with the arbiter of the each of the
3 selected non-empty virtual output queues of each of the

4 selected virtual output queue groups, an outgoing link from
5 among the one or more candidate outgoing links, is done in
6 accordance with a round robin discipline.

1 Claim 15 (original): The method of claim 10 wherein the
2 acts of

- 3 a) sending, on behalf of each non-empty virtual
4 output queue, a request to slave arbiters, each of the
5 slave arbiters being associated with one of each of
6 the outgoing links of the input module, and each of
7 the slave arbiters being associated with the group of
8 virtual output queues to which the non-empty virtual
9 output queue belongs;
- 10 b) sending, on behalf of each group of virtual output
11 queues to which a non-empty virtual output queue
12 belongs, a request to master arbiters, each of the
13 master arbiters being associated with one of each of
14 the outgoing links of the input module;
- 15 c) selecting, with each of the master arbiters, a
16 virtual output queue group having at least one
17 non-empty virtual output queue, from among one or more
18 virtual output queue groups that sent a request;
- 19 d) selecting, with each of the slave arbiters, a
20 non-empty virtual output queue, belonging to its
21 associated group, from among one or more virtual
22 output queues that sent a request; and
- 23 e) selecting, with the arbiter of the each of the
24 selected non-empty virtual output queues of each of
25 the selected virtual output queue groups, an outgoing
26 link from among the one or more candidate outgoing
27 links, each of the one or more candidate outgoing

28 links being associated with a master arbiter that
29 selected the virtual output queue group and a slave
30 arbiter that selected the non-empty virtual output
31 queue,
32 are performed at least twice within one cell time slot.

1 Claim 16 (original): A combination for use in a
2 multi-stage switch, the combination comprising:
3 a) a plurality of central modules, each including
4 outgoing links towards output modules including a
5 plurality of output ports, the output modules
6 collectively including $k \times n$ output ports;
7 b) a plurality of input modules, each including
8 i) k groups of n virtual output queues, and
9 ii) outgoing links coupled with each of the
10 plurality of central modules;
11 c) means for matching a non-empty virtual output
12 queue of the input module with an outgoing link in the
13 input module, the means for matching a non-empty
14 virtual output queue of the input module with an
15 outgoing link in the input module including
16 i) master arbiters, each of the master arbiters
17 being associated with one of the outgoing links,
18 for selecting a group of virtual output queues
19 from among those associated with a received
20 request,
21 ii) groups of slave arbiters, each group of
22 slave arbiters being associated with one of the k
23 groups of n virtual output queues, for selecting
24 a virtual output queue from among those
25 submitting a request, and

26 iii) virtual output queue arbiters, each virtual
27 output queue arbiter being associated with one of
28 the virtual output queues, for selecting an
29 outgoing link from among those submitting a
30 grant; and
31 d) means for matching the outgoing link of the input
32 module with an outgoing link of one of the central
33 modules.

1 Claim 17 (original): The combination of claim 16 wherein
2 the means for matching a non-empty virtual output queue of
3 an input module with an outgoing link in the input module
4 further include:
5 iv) means for sending, on behalf of each
6 non-empty virtual output queue, a request to
7 slave arbiters, each of the slave arbiters being
8 associated with one of the outgoing links of the
9 input module, and each of the slave arbiters
10 being associated with one of the groups of
11 virtual output queues; and
12 v) means for sending, on behalf of each of the
13 groups of virtual output queues to which a
14 non-empty virtual output queue belongs, a request
15 to master arbiters, each of the master arbiters
16 being associated with one of the outgoing links
17 of the input module.

1 Claim 18 (original): The combination of claim 16 wherein
2 the means for matching a non-empty virtual output queue of
3 an input module with an outgoing link in the input module
4 performs the match within one cell time slot.

1 Claim 19 (original): The combination of claim 16 wherein
2 each of the master arbiters operates in accordance with a
3 round robin discipline.

1 Claim 20 (original): The combination of claim 19 wherein
2 each of the master arbiters operates independent of the
3 others.

1 Claim 21 (original): The combination of claim 16 wherein
2 each of the slave arbiters operates in accordance with a
3 round robin discipline.

1 Claim 22 (original): The combination of claim 21 wherein
2 each of the slave arbiters operates independent of the
3 others.

1 Claim 23 (original): The combination of claim 16 wherein
2 each of the virtual output queue arbiters operates in
3 accordance with a round robin discipline.

1 Claim 24 (original): The combination of claim 23 wherein
2 each of the virtual output queue arbiters operates
3 independent of the others.

1 Claim 25 (original): The combination of claim 16 wherein
2 the means for matching a non-empty virtual output queue of
3 the input module with an outgoing link in the input module
4 performs multiple matching iterations within one cell time
5 slot.

1 Claim 26 (original): The combination of claim 16 wherein
2 the means for matching the outgoing link with an outgoing
3 link of one of the central modules include:
4 i) means for sending a request for the outgoing link of
5 the input module to an arbiter for each of the outgoing
6 links of the central modules that leads towards an output
7 port associated with the virtual output queue matched
8 with the outgoing link of the input module; and
9 ii) for each of the outgoing links of the central
10 module, an arbiter for selecting an outgoing link of the
11 input module from among those that sent a request.

1 Claim 27 (original): The combination of claim 16 wherein
2 there are:
3 k input modules, each having n input ports, k
4 groups of n virtual output queues, and m outgoing links.

1 Claim 28 (original): An input module for use a multi-stage
2 switch including a plurality of central modules, the input
3 module comprising:
4 a) k groups of n virtual output queues;
5 b) outgoing links coupled with each of the plurality
6 of central modules; and
7 c) means for matching a non-empty virtual output
8 queue of the input module with an outgoing link in the
9 input module, the means for matching a non-empty
10 virtual output queue of the input module with an
11 outgoing link in the input module including
12 i) master arbiters, each of the master arbiters
13 being associated with one of the outgoing links,

14 for selecting a group of virtual output queues
15 from among those submitting a request,
16 ii) groups of slave arbiters, each group of
17 slave arbiters being associated with one of the k
18 groups of n virtual output queues, for selecting
19 a virtual output queue from among those
20 submitting a request, and
21 iii) virtual output queue arbiters, each virtual output
22 queue arbiter being associated with one of the virtual
23 output queues, for selecting an outgoing link from among
24 those associated with a received grant.

1 Claim 29 (original): The input module of claim 28 wherein
2 the means for matching a non-empty virtual output queue of
3 an input module with an outgoing link in the input module
4 performs such matching within one cell time slot.

1 Claim 30 (original): The input module of claim 28 wherein
2 each of the master arbiters is updated in accordance with a
3 round robin discipline.

1 Claim 31 (original): The input module of claim 30 wherein
2 each of the master arbiters operates independent of the
3 others.

1 Claim 32 (original): The input module of claim 28 wherein
2 each of the slave arbiters is updated in accordance with a
3 round robin discipline.

1 Claim 33 (original): The input module of claim 32 wherein
2 each of the slave arbiters operates independent of the
3 others.

1 Claim 34 (original): The input module of claim 28 wherein
2 each of the virtual output queue arbiters is updated in
3 accordance with a round robin discipline.

1 Claim 35 (original): The input module of claim 34 wherein
2 each of the virtual output queue arbiters operates
3 independent of the others.

1 Claim 36 (original): The input module of claim 28 wherein
2 means for matching a non-empty virtual output queue of an
3 input module with an outgoing link in the input module
4 repeats such matching within one cell time slot.

1 Claim 37 (original): The input module of claim 28 wherein
2 there are k input modules, each having n input ports, and m
3 outgoing links.

Claim 38 (canceled)